HYCOM Code Development

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2005 HYCOM MEETING

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Report Documentation Page

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Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

HYCOM 2.2 (I)

- Maintain all features of HYCOM 2.1
  - Orthogonal curvilinear grids
  - Can emulate Z or Sigma or Sigma-Z models
    - It is "Arbitrary Lagrangian-Eulerian", see: Adcroft and Hallberg, O. Modelling 11 224-233.
  - Explicit support for 1-D and 2-D domains
  - KPP or Kraus-Turner or Mellor-Yamada 2.5 or Price-Weller-Pinkel
  - Rivers as bogused surface precipitation
  - Multiple tracers
  - Off-line one-way nesting
  - Scalability via OpenMP or MPI or both
    - Bit-for-bit multi-cpu reproducibility
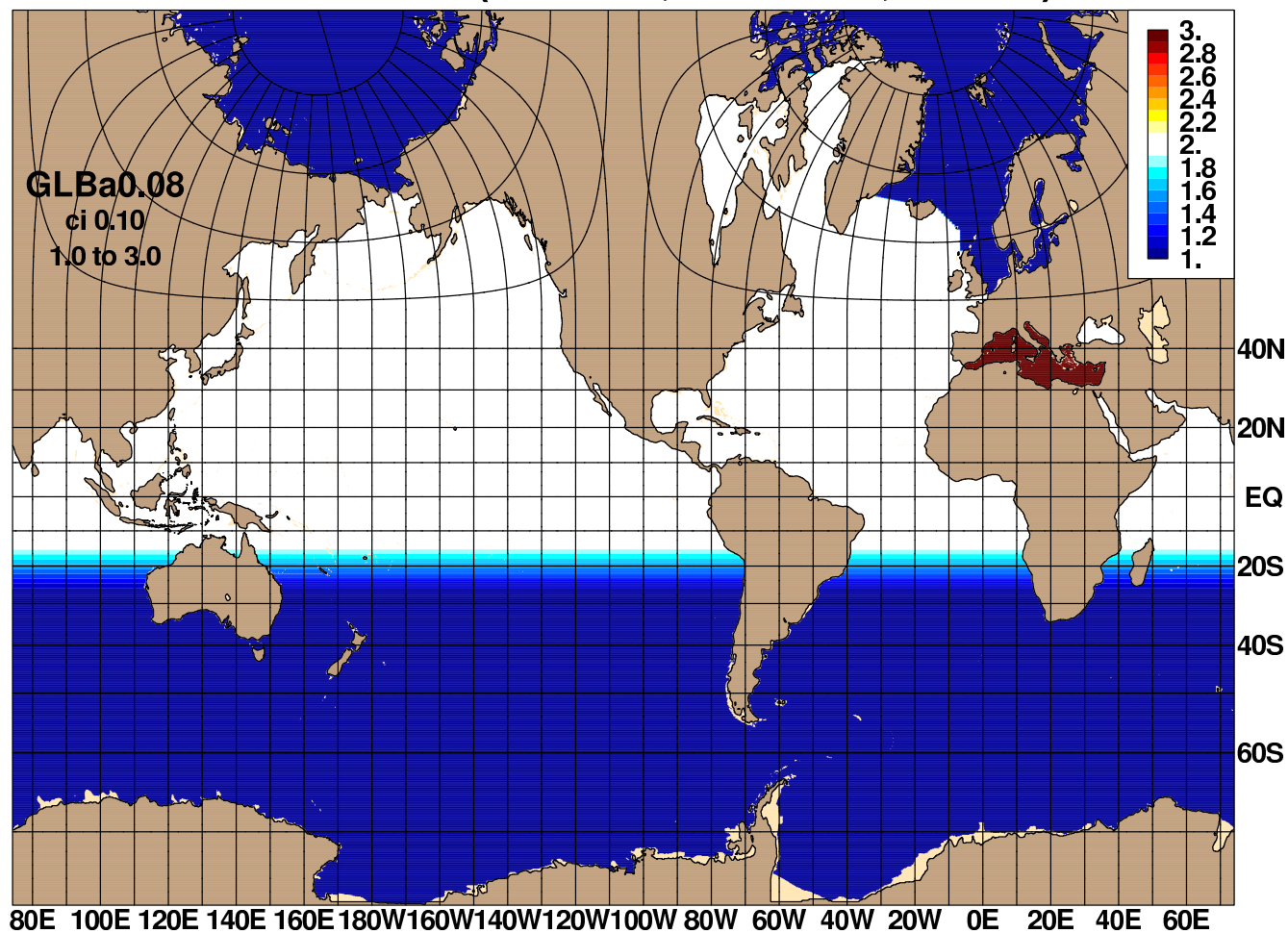
HYCOM 2.2 (IIa)

- Alternative scalar advection techniques

  - Donor Cell, FCT (2nd and 4th order), MPDATA
  - FCT2 replaces MPDATA as standard scheme

- Vertical coordinate changes

  - Vertical remapping uses PLM for fixed coordinate layers
  - Thin deep iso-pycnal layers
  - Stability from locally referenced potential density
  - Spatially varying layer target densities
    - ◇ Different isopycnal layers in semi-enclosed seas

HYCOM 2.2 (IIb)

- Special halo exchange for tripole global grid

  - Arctic dipole patch on standard Mercator globe
  - Logically rectangular domain
    - Two halves of top edge "fold" together
    - V-velocity changes sign across the fold

- Improved thermobaricity

  - No single reference state is approriate for the global ocean
    - Hallberg, Ocean Modelling, 8, 279-300
  - Use a linear combination of two out of three reference states
    - Atlantic $\quad\quad$ ($3°$C, 35.0 psu)
    - Arctic/Antarctic $\quad$ ($0°$C, 34.5 psu)
    - Mediterranean $\quad$ ($13°$C, 38.5 psu)
  - Most locations use just one reference state
    - Linear combinations allow smooth transition between states
      - Do this in shallow water if possible
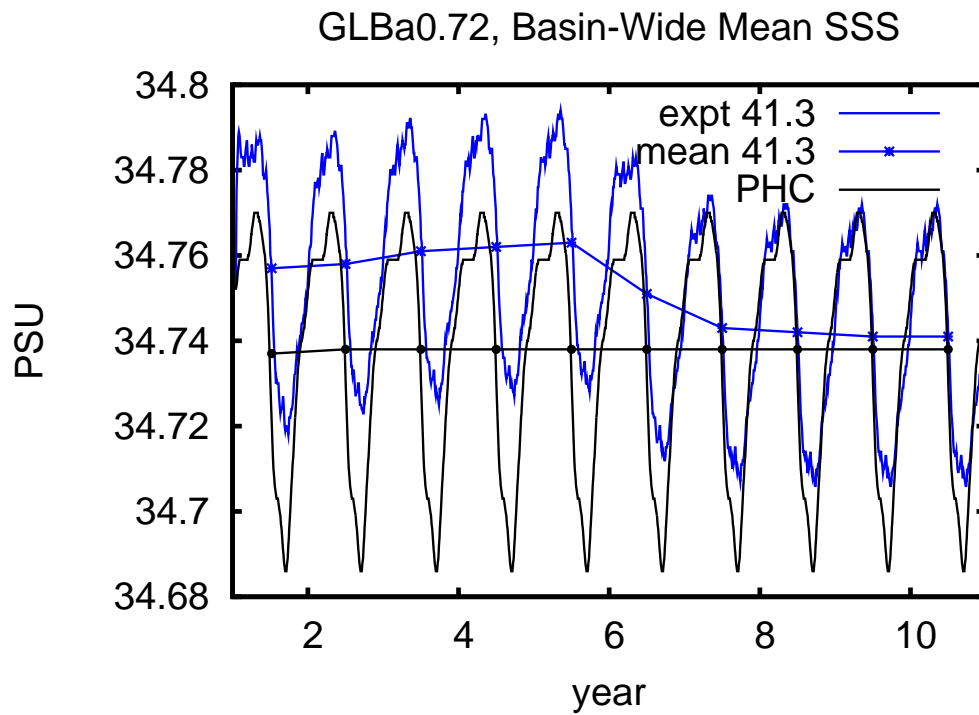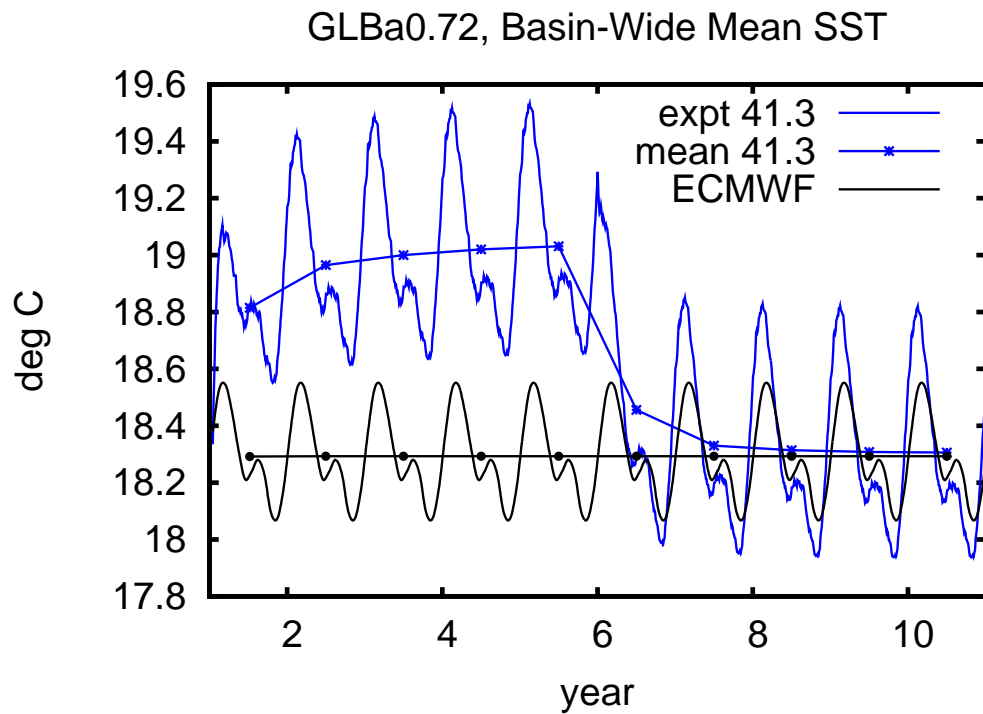
1/12° GLOBAL THERMOBARIC REFERENCE STATE

TBARIC MAP (1=Arctic,2=Atlantic,3=Med.)
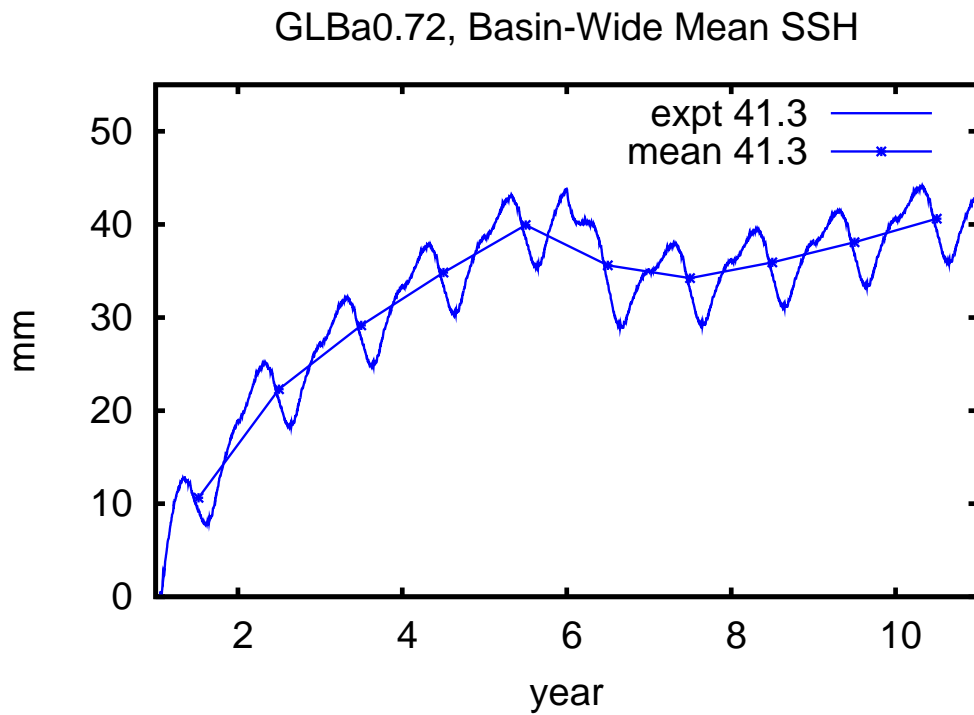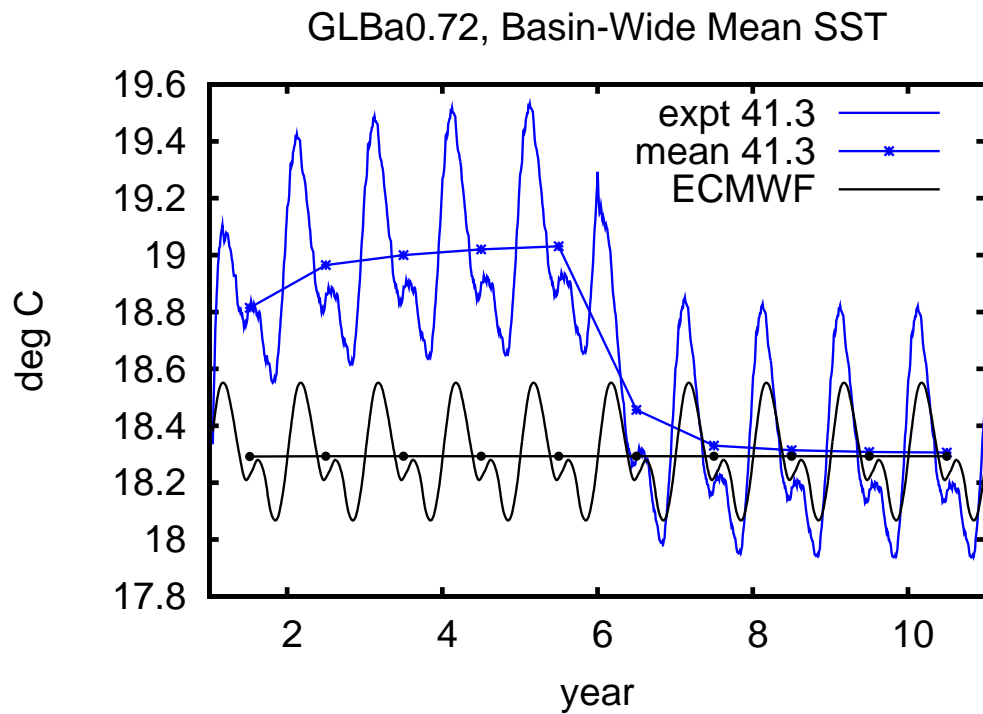

GLBa0.08
ci 0.10
1.0 to 3.0

HYCOM 2.2 (IIIa)

- Mixed layer changes

  - GISS mixed layer model
  - KPP bottom boundary layer
  - KPP tuning

- Atmospheric forcing changes

  - Option to input ustar fields
    - ◇ Otherwise calculated from wind stress or speed
  - Can relax to observed SST fields
  - Improved COARE 3.0 bulk exchange coefficients
  - Black-body correction to longwave flux
  - Climatological heat flux offset, $\overline{Q}_c$
$$Q = (Q_{sw} - Q_{lw}) + (Q_l + Q_s) + \overline{Q}_c$$
    - ◇ $\overline{Q}_c$ is constant in time
      - · Typically based on the model's climatological SST error, times (say) -45 $Wm^{-2}/{}^{\circ}C$

$\overline{Q}_c$ ADDED AFTER FIVE YEARS
GLOBAL MEAN SST and SSS

GLBa0.72, Basin-Wide Mean SST

GLBa0.72, Basin-Wide Mean SSS

$\overline{Q}_c$ ADDED AFTER FIVE YEARS
GLOBAL MEAN SST and SSH

GLBa0.72, Basin-Wide Mean SST

GLBa0.72, Basin-Wide Mean SSH

HYCOM 2.2 (IIIb)

- Improved support for rivers

  ○ Still bogused surface precipitation
  ○ High frequency inter-annual river flow allowed
    ◇ Add it to atmospheric precip, off-line
    ◇ Instead of monthly climatology,
       or in-addition to it (flow anomalies)
  ○ Better control of low salinity profiles
  ○ Option for mass (vs salinity) flux

- Finer control over energy loan ice model

  ○ Melting point can be linear in salinity
  ○ Set ice minimum and maximum thickness
  ○ Set ice vertical temperature gradient
    ◇ Or get ice surface temperature from T_a

- New diagnostics within HYCOM

  ○ Time-averaged fields (in archive files)
  ○ Synthetic instrumentation
    ◇ 3-D particle tracking
    ◇ surface and constant depth drifters
    ◇ isopycnic drifters
   ◇ fixed instruments and moorings

HYCOM 2.2 (IV)

- Climatological nesting now allowed

  - Start from monthly mean outer model archive files
  - Allows nested runs longer than the outer run
    - But with less accurate boundary state
  - Probably only suitable for regional nests

- Nesting no longer requires co-located grids

  - General archive to archive horizontal interpolation (curvilinear)

- Hybrid to fixed vertical grid remapper

  - Allows fixed-coordinate nests inside hybrid coordinate outer domains
   - HYCOM to (fixed-grid) HYCOM
    - HYCOM to NCOM

HYCOM 2.2 (V)

- Enhanced hycomproc and fieldproc

  - NCAR-graphics based
  - Many more color palette options
    - ◇ Can read in an arbitrary palette
  - Mark locations, and draw tracks, on plot
  - Plot diffusion coefficients and tracers (hycomproc)
  - Overlay vector and line-contours (fieldproc)

- Added fieldcell

  - Like fieldproc, but for cell-array (vs contouring)
  - Uses NCAR's map projections
  - Typically much faster than fieldproc,
    but can leave unfilled cells

ERA-15 SST: Feb

GLBa0.72
ci 0.35
-1.7 to 29.8

SSS (hour 0)

GLBa0.72
ci 0.040
32.47 to 36.99
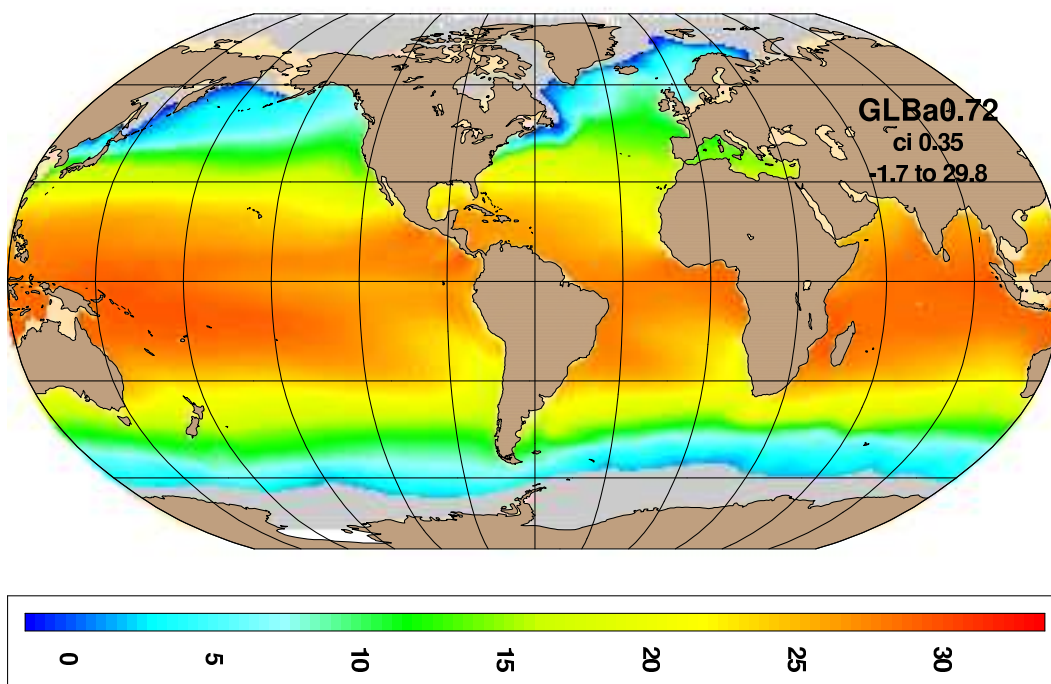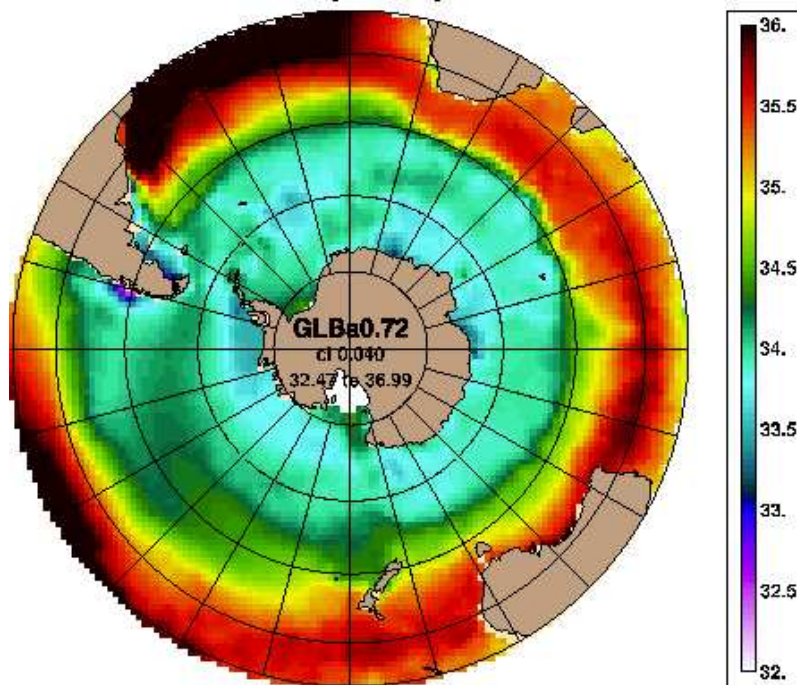
HYCOM 2.2 (VI)

- Diagnostic fields to netCDF and other file formats

  - Archive fields in layer space

    ◇ On p-grid (interpolated velocity)

  - 3-D archive fields interpolated to z-space

    ◇ On p-grid, or

    ◇ Sampled along arbitrary tracks

  - 3-D archive fields sampled on iso-therms

  - Meridional stream-function from (mean) 3-D archive

    ◇ In logical array space (rectilinear grids)

    ◇ Binned to latitude bands (curvilinear grids)

  - Atmospheric forcing input fields

    ◇ Time axis depends on ".b" file format

    ◇ Any ".a" file with the right ".b" file structure can be converted to netCDF

  - Fields binned into lon-lat cells

HYCOM CURVILINEAR GRIDS and NetCDF

- Most basin-scale cases use a Mercator grid

  - 1-D lat & lon axes (rectilinear)
  - Handled well by many netCDF packages

- Global HYCOM's Arctic patch grid is curvilinear

- HYCOM netCDF use the CF-1.0 conventions, which support curvilinear grids

  - If latitude and longitude are 2-D grids
    - 1-D axes are array indexes
    - Longitude and latitude arrays are also in the file and identified as alternative coordinates

- Most netCDF packages are not CF-1.0 aware

  - Bin into uniform lon-lat cells off-line
  - Interpolate to a 1-D latitude and longitude grid off-line
    - General archive to archive horizontal interpolation

- Archive to archive remapper can also be used for standard (non-native) grids

  - MERSEA grid is uniform $1/8°$
 - AOMIP grid is rotated uniform $1/2°$

GoM NESTED TEST DOMAIN

- Same resolution nesting unexpectedly useful

  - No need to rerun large domain
  - Change atmospheric forcing (e.g. use MM5)
  - Change vertical structure
  - Tracer studies (e.g. add biology)

- 1/12°: Gulf of Mexico inside Atlantic

  - Change from 20m to 5m coastline
  - Run for Aug 1999 to equilibrate
  - Run Sep-Nov as standard test case

- Used to test advection schemes

- All needed file are prebuilt

  - **ftp://hycom.rsmas.miami.edu/awall/hycom/GOMd0.08/**
  - Uses 2.1.20, and 2.1.34 is also available
  - Includes a passive tracer

- Also tested (new) climatological nesting

  - Start from monthly mean outer model archive files
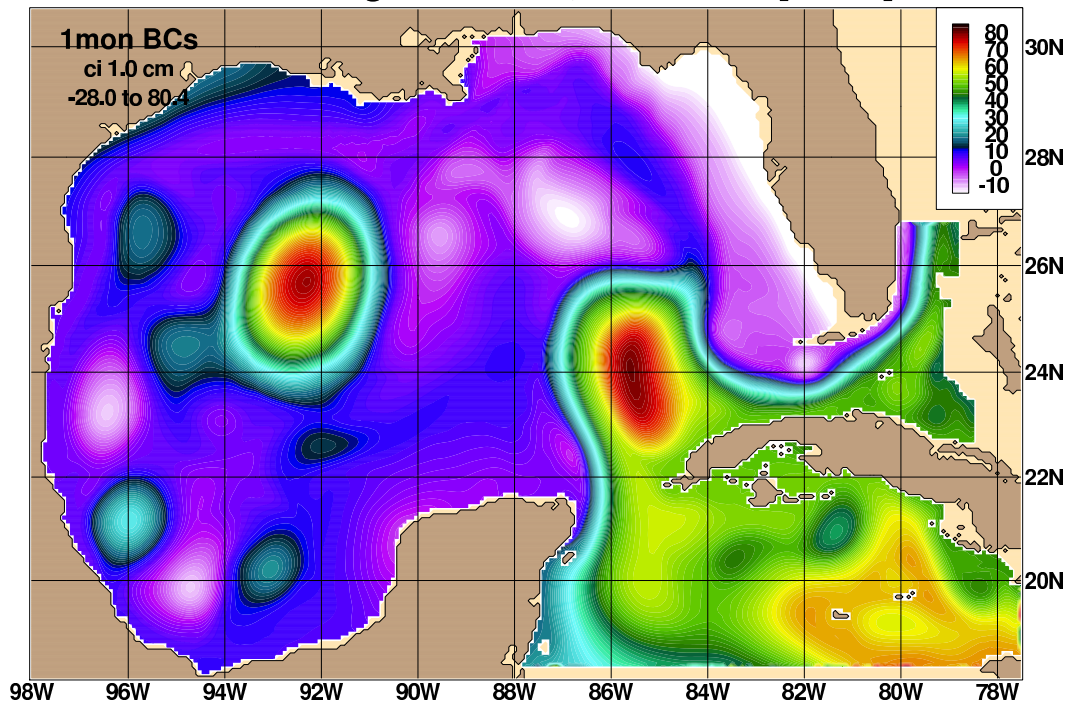 - Climatological nested boundary conditions

DAILY VS MONTHY NESTING
SSH after 3 Months
sea surf. height   Dec 01, 1999 00Z   [06.1H]
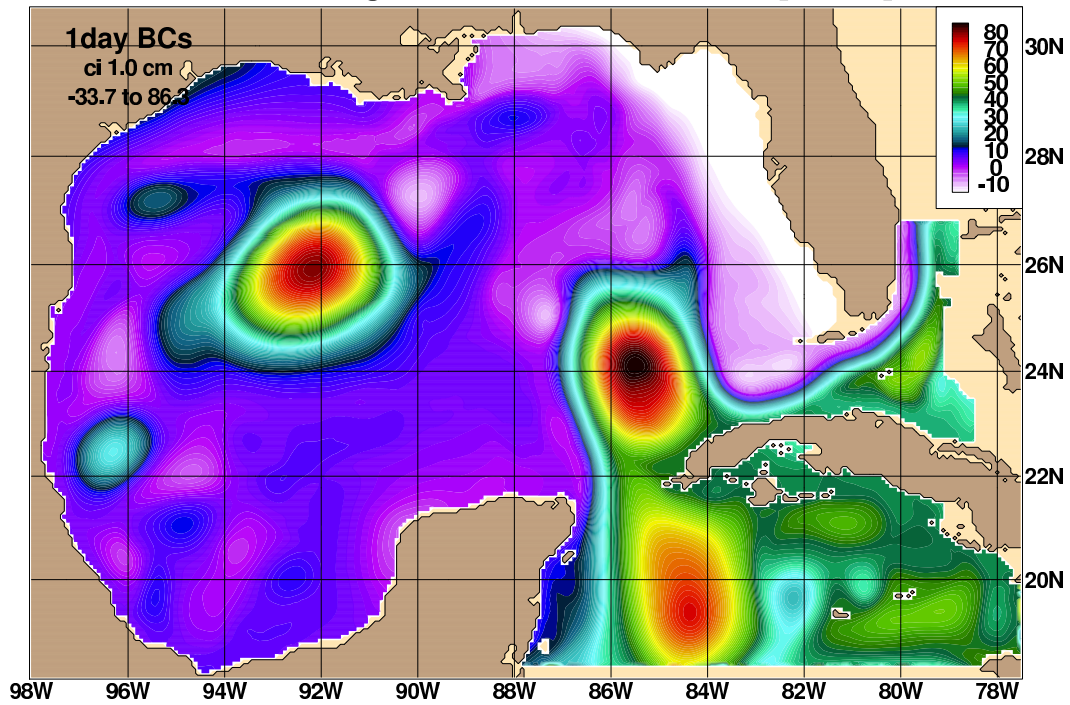
sea surf. height   Dec 01, 1999 00Z   [11.1H]

CANDIDATE FEATURES FOR HYCOM 2.3

- Stable-code vs new features

  - Released code-base has to be tested and stable
  - New features can be a significant improvement
  - Will add interim releases to web page
    - Features may be removed in next released code

- Fully region-independent

  - Compile once, run on any region and any number of processors
    - Run-time memory allocation
    - Might reduce performance (fewer compiler optimizations available)
  - Needed for full ESMF compliance

- Improve split-explicit time scheme

- Tidal forcing

- Diurnal heat flux cycle

- Equation of state that is quadratic in salinity

- Wind drag coefficient based on model SST

- Initial support for ESMF

HYCOM AND ESMF

- Earth System Modeling Framework
  http://www.esmf.ucar.edu/

  - Superstructure couples components
    - ◇ Air/Ocean/Ice/Land
    - ◇ Asynchronous I/O component
      - · Run "concurent" with model components
  - Infrastructure provides data structures
    and utilities for building scalable models

- Add a superstructure "cap" to HYCOM

  - Simplifies coupled systems
    - ◇ HYCOM coupled to LANL CICE sea-ice
    - ◇ Convert atmospheric field processing and the
      energy-loan ice model into ESMF components
  - Use ESMF for (user-level asynchronous) I/O
  - Interoperate with other ESMF compliant ocean
    models (e.g. Poseidon, MITgcm, MOM4)

- The initial ESMF support will be optional

  - HYCOM version 2.3

- ESMF will eventially required to run HYCOM

  - HYCOM version 3.0